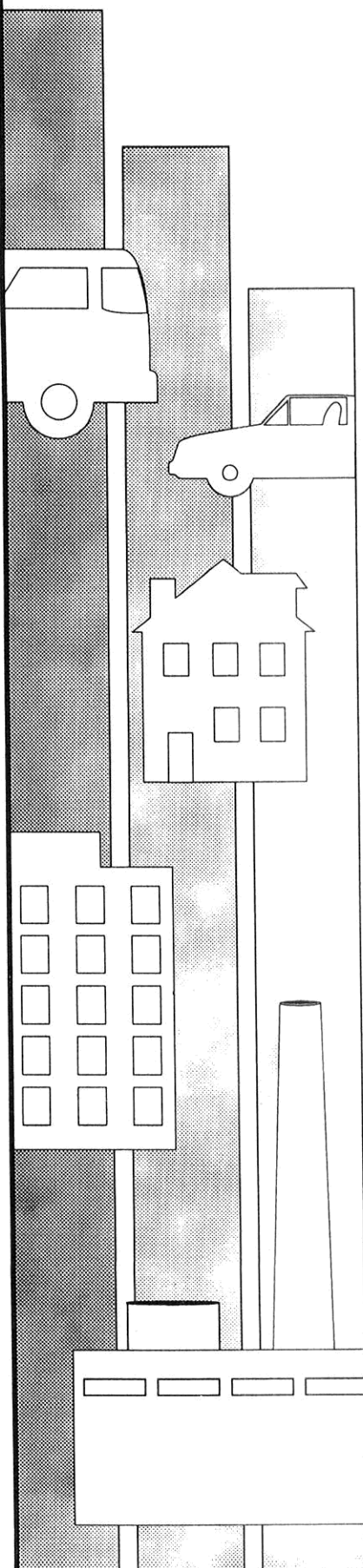


U.S. Department of Energy  
Office of Policy

# ENERGY EFFICIENCY IN THE U.S. ECONOMY



## TECHNICAL REPORT TWO

# EFFECTS OF FEEBATES ON VEHICLE FUEL ECONOMY, CARBON DIOXIDE EMISSIONS, AND CONSUMER SURPLUS

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February 1995



Printed with soy ink on recycled paper

This report was prepared in the Energy Analysis Program at Lawrence Berkeley Laboratory for the Department of Energy's Office of Energy Efficiency and Alternative Fuels Policy. Principal authors of this study are William B. Davis, Mark D. Levine, and Kenneth Train, in association with K.G. Duleep. Davis and Levine are affiliated with the Energy Analysis Program. Davis and Train are affiliated with the Department of Economics at the University of California, Berkeley, where Train is also Chair of the Center for Regulatory Policy. Duleep is affiliated with Energy and Environmental Analysis, Inc., in Arlington, Virginia.

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## EXECUTIVE SUMMARY

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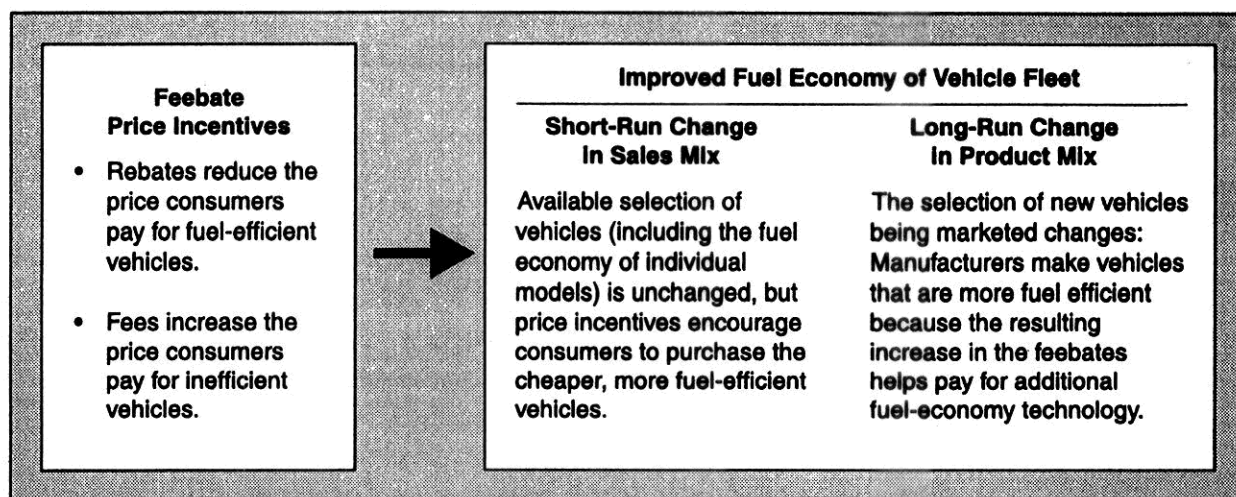
### Introduction

This report investigates the use of government feebate programs to increase the fuel economy of the U.S. fleet of private light-duty vehicles. A feebate (the term is a combination of “fee” and “rebate”) is a sliding-scale financial incentive that is added to, or subtracted from, the purchase price of a vehicle. The magnitude of the feebate is determined by the relative fuel economy of the vehicle. Feebates “tilt” the prices that consumers pay for new vehicles in favor of the more fuel-efficient ones. Gas-guzzlers are charged fees, which finance rebates for gas-sippers.

Feebates are intended to encourage both the purchase and the manufacture of more fuel-efficient vehicles. Consumers respond directly to feebates by purchasing more fuel-efficient vehicles. This short-run, demand-side response causes the composition of the fleet of new vehicles sold, or the *sales mix*, to shift in favor of greater fuel economy. Feebates reduce the price of fuel-efficient vehicles and raise the price of fuel-inefficient ones, and consumers respond by shifting their new vehicle purchases in favor of more fuel economy. Manufacturers respond to feebates by incorporating additional fuel-economy technologies in their vehicles. This long-run, supply-side response to feebates causes the characteristics of new vehicles, or *product mix*, to shift in favor of greater fuel economy. The feebates make fuel-economy technologies relatively less expensive for manufacturers to adopt, so manufacturers respond by shifting their production in favor of more fuel economy. These feebate-induced changes in product mix and sales mix both achieve the objective of improving the fuel economy of the vehicle fleet (Figure ES-1).

Feebates have been proposed in a variety of legislative bodies. In Maryland, a State feebate program has even been enacted, though it is currently facing a legal challenge on the grounds that it is preempted by Federal corporate average fuel economy (CAFE) legislation. California was the first State to propose feebates, with its DRIVE+ bill. Massachusetts, Maine, and Arizona also have or have had feebate legislation before their lawmakers. At the Federal level, there have been four bills that include feebate provisions, two in the House of Representatives and two in the Senate.

Feebates can be designed to vary in different manners with fuel consumption (gallons per mile, or gpm) or fuel economy (miles per gallon, or mpg). A



**Figure ES-1. How Feebates Result in a More Fuel-Efficient Fleet of Vehicles**

formula determines the actual feebate that any vehicle receives. Different feebate formulas will result in different incentives to consumers and manufacturers and thus will have different impacts. Estimating how consumers and manufacturers will respond to different feebate designs is a central aim of this study.

## Feebate Scenarios

To explore the ramifications of different feebate designs, this study examines six feebate approaches. Each is revenue-neutral—that is, the fees collected and the rebates disbursed are equal or nearly so. Revenue neutrality is accomplished by the appropriate choice of the “zero point” in a feebate schedule. The zero point is the level of fuel economy at which neither a fee nor a rebate is applied. For levels of fuel economy that are higher than this zero point, a rebate is applied. For vehicles whose fuel economy is below the zero point, a fee is applied. The following are the six scenarios:

- **GPM LOW** is a consumption-based feebate. The purchase-price incentive varies in direct proportion to the vehicle’s fuel consumption, which is measured in gallons per mile. This feebate applies a different zero point to cars and to trucks. If the vehicle consumes less fuel per mile than this zero point, it receives a rebate; if it consumes more than the zero point, it is

assessed a fee. The feebate rate is set at \$50,000 per gpm. Thus, a vehicle whose fuel economy is 25 mpg—which translates to 0.04 gpm—would receive a \$500 greater rebate or lower fee than a vehicle that obtains 20 mpg—which is 0.05 gpm.

- GPM HIGH is the same as GPM LOW, except the feebate rate is set twice as high—namely, \$100,000 per gpm.
- ONE ZERO POINT is also a consumption-based feebate, with cars and trucks<sup>1</sup> pooled together for the calculation of the feebate. It calculates the feebates around the sales-weighted average of the entire fleet. ONE ZERO POINT is designed to provide an incentive for increased fuel economy comparable to GPM LOW and is intended to isolate the effects of assigning feebates to cars and trucks separately.
- MPG LOW is an efficiency-based feebate. In this approach, feebates are proportional to fuel economy, which is measured in miles per gallon, the inverse of fuel consumption. The feebate rate is \$70 per mpg. At 26.7 mpg, this rate translates to \$50,000 per gpm, like under GPM LOW. At 37.8 mpg, the rate is equivalent to \$100,000 per gpm, like under GPM HIGH.
- NONLINEAR LOW varies the effective feebate rate over the range of possible fuel economies, increasing the rate in the range where most vehicles fall, and decreasing it in the extremes. This novel approach to feebate design has the effect of encouraging more mix shifting in the range where it will affect the most vehicles. The range of the NONLINEAR LOW feebates is similar to GPM LOW, and this range is considered to be the binding constraint on the size of the feebates. However, the average feebate rate under NONLINEAR LOW is similar to the rate under GPM HIGH. The NONLINEAR LOW feebate is calculated by comparing the vehicle's gpm with the zero point gpm, taking the square root of the difference, and multiplying by \$8,000 per gpm. If the vehicle's gpm is higher than the zero point, then the resulting quantity is a rebate; otherwise it is a fee.
- SIZE-BASED applies feebates in proportion to fuel consumption per unit of interior volume. This size indexing has been proposed as a means of lessening the adverse impacts of consumption-based feebates on domestic manufacturers, whose vehicles tend to be larger than foreign-made vehicles and to consume more fuel. This scenario is designed to be most comparable with GPM LOW. Because it is difficult to determine a size measure that applies equally well to both cars and trucks, the GPM LOW

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<sup>1</sup>All references to trucks are to private light-duty trucks.

feebates are applied to trucks in the SIZE-BASED scenario to make it easier to compare SIZE-BASED with GPM LOW and the other scenarios.

Together, these six scenarios provide a comprehensive examination of many possible variations of feebate programs intended to encourage vehicle fuel economy. For each feebate approach, this study provides quantitative estimates of the effects on fuel economy, fuel consumption, carbon dioxide (CO<sub>2</sub>) emissions, and consumer surplus (a measure, in dollars, of the net benefits obtained by consumers in the vehicle market). The report does not attempt to compare feebates with other policies, such as CAFE standards or gasoline taxes, that have similar goals.

To forecast the characteristics of the U.S. vehicle fleet under the different feebate scenarios, this study uses an integrated supply and demand model called the Automobile Use, Technologies, and Ownership (AUTO) model. The supply component of the model combines data on individual households with data on vehicles and fuel prices to forecast the price, fuel economy, power, and other attributes of vehicles that manufacturers offer. The demand component then forecasts the number and type of vehicles that households demand by vehicle size, performance level, and other attributes, as well as the miles that the vehicles are driven. The combined supply and demand model forecasts the average fuel economy of new vehicles and the fleet of all vehicles, the total fuel consumption and CO<sub>2</sub> emissions of these vehicles, consumer surplus, and manufacturer market share and sales. The forecasts assume that the feebate program begins in 1995, and they project the results for each year through 2010.

To determine the effects of the different feebate programs, each feebate scenario is compared to a reference forecast, called BASELINE, that assumes no policy changes that would affect the market. The impacts of each feebate are calculated as the difference between each of the six feebate scenarios and the reference forecast.

## General Effects of Feebates

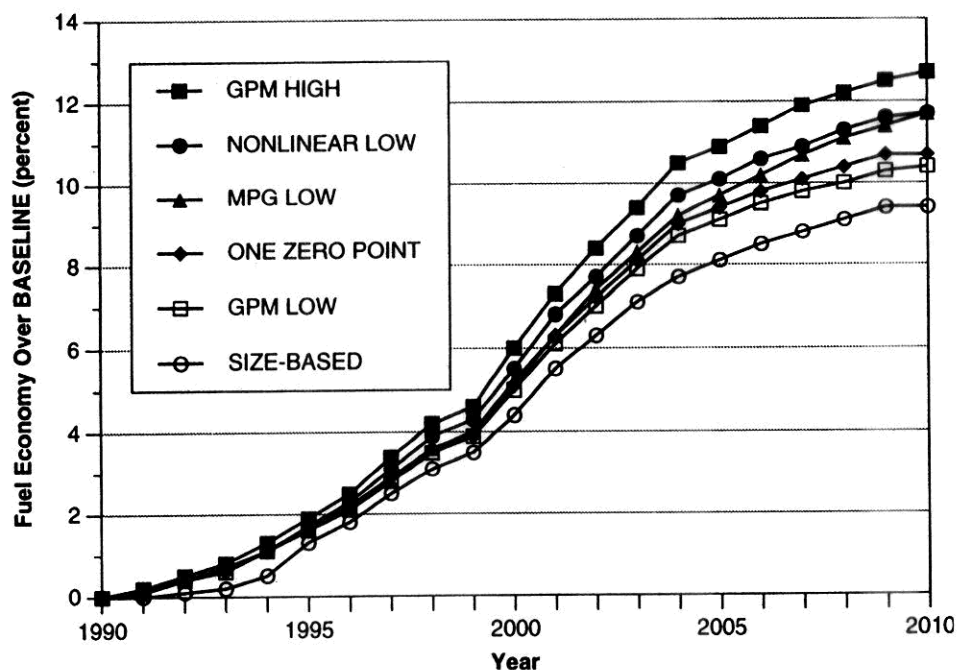
The analysis of the six feebate scenarios leads to the following general conclusions about the effects of feebate programs:

- By 2010, the average fuel economy of new vehicles improves between 11 and 18 percent relative to a baseline forecast without feebates.

- The manufacturer response (manufacturers designing their vehicles to be more efficient) accounts for the majority of this improvement.
- The consumer response (consumers shifting their purchases to more efficient vehicles) is estimated to account for only a 1- to 2-percent improvement in the average fuel economy of new vehicles.
- The fuel economy of the entire stock of on-road vehicles also improves, but more slowly, as the new, more efficient vehicles are gradually added to the vehicle stock.
- Because the cost of driving is reduced, people travel more; this increased travel takes back 25 percent of the fuel savings.
- Even with the increased travel, fuel savings achieved under these feebate scenarios reach 6 billion to 8 billion gallons per year in 2010.
- Between 1995 and 2010, cumulative CO<sub>2</sub> emissions are reduced by 660 million to 890 million tons under most scenarios.
- Consumers are estimated to benefit from feebates; estimated consumer benefits from fuel savings outweigh the costs of feebates.
- Total new-vehicle sales increase slightly at first, then decrease later in the forecast period. When discounted and summed over the entire period, sales decrease in most scenarios.
- Foreign manufacturers capture a slightly larger share of sales under most scenarios.

The average fuel economy of new vehicles increases more quickly after the introduction of feebates, with stock on-road fuel-economy increases following as these new, more fuel-efficient vehicles are added to the vehicle stock. By the end of the forecast period (2010), the fuel economy of new cars improves by 12 to 18 percent, and the fuel economy of new trucks improves by 11 to 13 percent. By adding more fuel-efficient vehicles to the stock of vehicles, feebates result in a 9- to 13-percent improvement in stock on-road fuel economy. These improvements are charted in Figure ES-2. This figure shows the average, on-road fuel-economy improvement for all new and used vehicles, including both cars and trucks.

Nearly all the improvement in fuel economy comes from manufacturers installing more fuel-economy technologies in response to the feebates. This is because feebates make many fuel-economy technologies cost-effective that otherwise would not be so. With the feebates, manufacturers are expected to adopt these technologies, raising the fuel economy of the vehicles that they



**Figure ES-2. Feebate-Induced Improvements in Fuel Economy of Entire Vehicle Stock Under All Scenarios**

offer. The magnitude of the manufacturer response results from the underlying analysis of fuel-economy technologies that are close to cost-effective given current forecasts of fuel prices and vehicle travel. Varying the estimates of the cost of fuel-economy technologies and the effects of these technologies on vehicle mileage (mpg) could significantly alter estimates of manufacturer response. Such sensitivity analysis represents a potentially important area for future research, but was beyond the scope of this analysis.

Only a small portion of the fuel-economy increase is attributable to consumers changing their choice of vehicle. Models that consumers typically choose between generally have approximately the same size, power, and other features, and they generally obtain close to the same level of fuel economy. The feebate therefore is about the same for similar vehicles and does not significantly affect consumer choice among these vehicles. Feebates differ more widely among vehicles with different characteristics, but consumers will not readily switch to very different vehicles in response to feebates of the magnitudes analyzed in this study. The consumer response accounts for only a 1- to 2-percent improve-

ment in fleet average new vehicle fuel economy. This finding underscores the importance of understanding the manufacturer response.

The improvement in fuel economy reduces the consumer's cost of driving. Consequently, the miles that a vehicle is driven increase. Specifically, this analysis estimates that about 25 percent of the drop in fuel consumption that would result from the fuel-economy improvement is "lost" through consumers driving more. This "loss," of course, constitutes a benefit to consumers (which is included in the calculation of benefits).

Even with this increased driving, the fuel-economy improvements result in large reductions in gasoline consumption and CO<sub>2</sub> emissions. All scenarios are found to avoid 60 million to 80 million tons of CO<sub>2</sub> emissions annually by 2005 because of a reduction in fuel consumption of 6.3 billion to 8.2 billion gallons of gasoline per year. This amounts to a 6- to 8-percent fuel savings.

Auto consumers are estimated to derive net benefits from feebates in all scenarios. This is because the efficiency gains brought about by the feebates are estimated to yield discounted fuel cost savings that are greater than vehicle cost increases. Feebates are estimated to cause consumer surplus to increase for all households.

Consumer surplus incorporates the cost to manufacturers of adopting fuel-economy technologies. In particular, manufacturers are assumed to increase the price of their vehicles to cover the cost of any technologies that they incorporate into the vehicles. Consumer surplus measures the effect on consumers of the change in prices, fuel economy, and other attributes of the vehicles that are offered to them. As such, consumer surplus incorporates the effect of the feebates themselves, the benefits to the consumer of fuel-economy improvements, and the cost of the new technologies that manufacturers incorporate, which are passed on through higher prices.

Increases in consumer surplus resulting from the application of feebates reflect a market condition in which consumers demand more fuel economy than they are able to purchase given the available set of vehicle choices. In this analysis, empirically derived consumer demand functions and producer supply functions for fuel economy suggest that this condition is indeed present in the baseline case. However, estimated consumer surplus benefits of feebates (as well as all forecasts of the analysis) could be higher or lower under alternative sets of assumptions regarding consumer and producer behavior.



Peak benefits to U.S. households reach \$70 to \$90 per year per household in the various scenarios and, in several scenarios, total more than \$10 billion annually when summed over all households. These benefits do not include external (for example, environmental) benefits and macroeconomic effects. The administrative cost of the program is also not included, but would be much smaller.

The consumer surplus benefits accrue more to higher income households, because such households purchase more vehicles and travel more. Poor households, however, receive a larger proportional increase—the benefit they receive is a larger *share* of their incomes.

The effects of feebates are slightly negative for domestic manufacturers. Because foreign manufacturers begin with more fuel-efficient fleets, they initially capture higher feebates. In 1995, purchasers of domestic vehicles pay an average fee of \$80 to \$170 in the six scenarios, while purchasers of foreign vehicles receive an average rebate of \$150 to \$300. This causes a transfer between U.S. consumers—not a direct transfer from domestic to foreign manufacturers.

Except in the SIZE-BASED scenario, discounted sales of domestic vehicles decrease slightly. That is, domestic manufacturers are hurt by most of the feebate schedules. The loss of discounted sales is less than 2 percent in all scenarios.

## Estimated Effects of the Six Feebate Scenarios

On balance, all six feebate programs examined in this study are estimated to provide net benefits to the U.S. economy and society. However, because each is designed differently, their effects are not identical. This section discusses the specific results forecast for each scenario. Table ES-1 presents a summary comparison.

### GPM LOW

Overall, GPM LOW feebates reduce gasoline consumption and CO<sub>2</sub> emissions considerably, increase consumer welfare substantially, and decrease the sales of

domestic manufacturers very slightly. Under the GPM LOW feebate, in 1995 the highest fee for car subclasses is about \$430; for truck subclasses, the highest fee is \$720. The highest rebate for any car subclass is \$760 and for any truck subclass is \$880.<sup>2</sup>

Compared with the level of fuel economy that would occur without the feebate, GPM LOW increases the fuel economy of new cars 13 percent by the year 2000 and 14 percent by 2010. New-truck fuel economy increases by 8 percent by 2000 and 11 percent by 2010 over the baseline.

Of the 14-percent improvement in new-car fuel economy in 2010, 13 percent is due to manufacturers' response, and only 1 percent is due to consumers' response. With the more fuel-efficient cars and trucks entering the on-road vehicle stock, the average fuel economy for the stock of cars increases by 13 percent by the year 2010; for trucks the improvement is 8 percent.

By 2010, the overall increase in fuel economy caused by the feebate reduces fuel consumption by approximately 6.9 billion gallons annually, and consequently reduces CO<sub>2</sub> emissions by 69 million tons annually.

Consumer surplus increases by an annual \$82 per household by 2010 as a result of the GPM LOW feebates. When cumulated over all households, this net benefit approaches \$10 billion annually by 2005. Over the entire forecast period, the GPM LOW feebates provide a cumulative net benefit of \$51 billion (1990 dollars in 1995) when discounted at 8 percent per year. Consumer surplus increases for all income groups. High-income groups receive the largest absolute increase, while middle- and low-income groups receive a larger relative increase (in percent terms).

Because consumers favor the more efficient vehicles produced under feebates, new-vehicle sales are stimulated in the early years of the feebates. During the first few years after the introduction of GPM LOW feebates, new-vehicle sales are expected to increase by close to 2 percent over the baseline. This increase in sales diminishes as the more efficient vehicles penetrate the entire stock and used vehicles become more attractive. This trend eventually (by 2001) causes new-vehicle sales to decrease relative to the baseline. By 2010, new-vehicle sales reach a low of 3.5 percent below baseline sales. Total sales over the entire period are forecast to decrease by 0.5 percent. For evaluating the effects on manufacturers, the discounted sales stream is most relevant.

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<sup>2</sup>Note that a subclass averages the characteristics of the vehicles it contains. This average reduces the maximum fees and rebates in all scenarios. If the feebate program were implemented, these maximum fees and rebates would be larger.

Table ES-1. Comparison of Feebate Scenarios

Factor	GPM LOW	GPM HIGH
<b>Feebate Rate</b>	\$50,000 per gpm (cars and trucks treated separately)	\$100,000 per gpm (cars and trucks treated separately)
<b>Increase in Fuel Economy, 2010 (percent)</b>		
New Cars	14	18
New Trucks	11	13
Entire On-Road Vehicle Stock	10	13
<b>Fuel Savings, 2010 (billion gallons)</b>	6.9	8.2
<b>Total CO<sub>2</sub> Emissions Reduction, 1995–2010 (million tons)</b>	750	890
<b>Discounted Change in New-Vehicle Sales, 1995–2010 (percent)</b>		
Total	–0.7	–0.2
Domestic	–1.3	–1.0
Foreign	0.4	1.4
<b>Benefits to Consumers (1990\$)</b>		
Per Household, Annually in 2010 (\$)	82	91
All Households, Annually in 2010 (billion \$)	10.0	11.1
Cumulative Discounted Total, 1995–2010 (billion \$)	51	56

ONE ZERO POINT	MPG LOW	NONLINEAR LOW	SIZE-BASED
\$50,000 per gpm (cars and trucks grouped together)	\$70 per mpg (cars and trucks treated separately)	Rate varies, averaging about \$100,000 per gpm, with highest rate applied at mid- range of fuel consumption (cars and trucks treated separately)	\$3.75 million per gpm per ft <sup>3</sup> of interior volume (applies to cars only—GPM LOW for trucks)
14	18	16	12
11	11	12	11
11	12	12	9
7.1	7.7	7.7	6.3
770	800	830	660
0.2	0.0	0.1	-0.8
-0.1	-0.7	-0.5	0.2
0.8	1.3	1.2	-3.2
75	87	90	70
9.1	10.6	11.0	8.5
47	52	55	43

Using an 8-percent discount rate, cumulative discounted sales over the 1995–2010 period drop by 0.7 percent compared with the baseline.

In 1995, the GPM LOW feebates result in an average fee of \$80 on domestic vehicles, which in effect subsidizes an average rebate of \$150 on foreign vehicles. Over time, domestic manufacturers are predicted to make up some of the difference by capturing the larger untapped fuel-economy potential in their vehicles. However, a disparity is forecast to remain through 2010. As a result of this difference, foreign manufacturers show a relative increase in sales with feebates. When discounted and summed over the entire forecast period, sales of domestic vehicles drop by 1.3 percent, while sales of foreign vehicles rise by 0.4 percent.

## ***GPM HIGH***

Although the GPM HIGH feebate rate is twice as high as the rate for GPM LOW, the maximum fees and rebates are less than twice as high as in GPM LOW because manufacturers install more fuel-economy technologies in their vehicles under GPM HIGH than under GPM LOW, which reduces the range of fuel consumption in the new-vehicle fleet.

Doubling the feebate rate does not come close to doubling the impact of the feebates. In the GPM HIGH scenario, new-car fuel economy increases 18 percent by 2010, while new-truck fuel economy increases 13 percent. The comparable figures for the GPM LOW scenario are 14 percent for new cars and 11 percent for new trucks.

Similarly, doubling the feebate rate brings about only a one-fifth greater impact in fuel savings and emissions reductions—from 6.9 billion gallons of gasoline saved in 2010 under GPM LOW to 8.2 billion under GPM HIGH, and from a cumulative reduction of 750 tons of CO<sub>2</sub> to 890 tons of CO<sub>2</sub>.

As with GPM LOW, nearly all the improvement in new-vehicle fuel economy is due to manufacturers adopting fuel-economy technologies. Of the 18-percent improvement in new-car fuel economy, 16 percent is attributable to manufacturer response, and only 2 percent is due to consumer response. Note that the consumer response is nearly double what it is under GPM LOW, while the manufacturer response is only slightly greater. Under GPM LOW, manufacturers' adoption of fuel-economy technologies improves new-car fuel economy by 13 percent relative to the baseline of no feebates. Under GPM HIGH, this manufacturer-induced improvement is only three percentage

points higher at 16 percent. The reason for this small difference is that most available fuel-economy technologies already become cost-effective and are adopted by manufacturers under the GPM LOW feebates; only a few more technologies became cost-effective for manufacturers under the GPM HIGH feebates. Although doubling the feebate rate does not significantly change the manufacturer response, it does double the response of consumers. Under GPM LOW, consumer response accounts for a 1-percent improvement in new car CAFE, while a 2-percent improvement is attained under GPM HIGH. However, because consumer response is a small share of the total response, the additional impact of doubling the feebates remains relatively small.

Compared with the baseline forecast, consumers benefit from the GPM HIGH feebates by an amount equal to \$91 per household annually by 2010. This increase in consumer surplus is 11 percent higher than it is under GPM LOW—implying that doubling the feebate rate results in net consumer benefits, even though the benefits do not double. The distribution of impacts is similar to GPM LOW.

The discounted cumulative sales of new vehicles (for all manufacturers) is forecast to decrease 0.2 percent. This change can be broken down into a 1.0-percent decrease in sales of vehicles produced by domestic manufacturers and a 1.4-percent increase in sales of vehicles produced by foreign manufacturers.

### **ONE ZERO POINT**

In the GPM LOW and HIGH feebates, different zero points are used for cars and trucks. As a result, a truck with the same fuel economy as a car could receive a rebate, while the car could be assessed a fee. Because trucks generally have lower fuel economy than cars, separate zero points prevent trucks from bearing the larger burden of the fees. However, applying two zero points provides an incentive for purchasing a truck to households who might otherwise be close to indifferent between a car and a truck. This causes a small increase in purchases of vehicles with lower fuel economy (those households induced to buy a truck rather than a car), which is counter to the objective of the feebate. As it turns out, however, the magnitude of this effect is not large.

The ONE ZERO POINT feebates apply the same feebate rate as GPM LOW to both cars and trucks. Under this formula, truck purchasers pay greater fees and receive smaller rebates than car buyers. The largest fee for a truck is \$1,120, while cars never pay a fee larger than \$250. No truck receives a rebate

in excess of \$500, while the highest rebate on a car is about \$940. In 1995, purchasers of domestic trucks pay \$1.2 billion in fees—more than what purchasers of *all* trucks pay in fees under the GPM HIGH scenario.

Under ONE ZERO POINT, the behavior of manufacturers is forecast to be the same as under GPM LOW feebates, because the feebate rate is the same under both. The values of the feebates are different, but the difference in feebates between two cars or two trucks remains unchanged. Because a given improvement in gpm reduces the vehicle fee, or increases its rebate, by the same amount under ONE ZERO POINT and GPM LOW, manufacturers adopt the same technologies under both feebate formulas. The choice of the zero point does not affect the response of the manufacturers—only the feebate rate does so.

The ONE ZERO POINT feebates have practically the same impacts as GPM LOW. Because only the (small) consumer response differs between these feebates, the ONE ZERO POINT feebates induce a shift in ownership shares of about 1 percent in favor of cars over trucks, compared with the shares under GPM LOW. This shift is due to consumers switching from trucks to cars. The shift, however, saves only about 200 million gallons of gasoline and 2 million tons of CO<sub>2</sub> emissions beyond that saved with the GPM LOW feebates in 2010. The sales impacts of ONE ZERO POINT on domestic manufacturers are no longer negative.

## **MPG LOW**

Because CAFE standards are specified in terms of miles per gallon, several feebate proposals have likewise been so specified. Such feebates are not proportional to fuel consumption. An increase from 10 to 11 mpg, for example, receives the same change in feebate as an increase from 60 to 61 mpg, despite the fact that the former saves 33 times as much fuel. Or stated differently, a gallon saved from an already fuel-efficient vehicle is valued more than a gallon saved from a less-efficient vehicle, placing a (potentially very high) premium on fuel-economy improvements in vehicles that are already fuel-efficient.

Unlike the case with other feebates, the range of feebates under MPG LOW increases as fuel economy increases over time. Under the MPG LOW program, the highest rebate on cars is nearly \$3,000, and the highest fee is about \$1,000; these extremes are both reached in 2010. This range is much greater than



under the GPM feebates, because the GPM feebates are proportional to fuel consumption while the MPG feebates are not: highly efficient cars (those with high mpg) receive a very large rebate under the MPG LOW feebate. For trucks, the highest rebate is \$1,500, and the highest fee is about \$500 (again, both occur in 2010). This range is smaller than under GPM HIGH and larger than under GPM LOW.

New-car fuel economy is forecast to improve by 18 percent under the MPG LOW feebates. This improvement is larger than that obtained under the GPM LOW and ONE ZERO POINT feebates and is about the same as that obtained with the GPM HIGH feebates.

New-truck CAFE is forecast to improve by 11 percent. This improvement is about the same as that obtained with GPM LOW and ONE ZERO POINT and is less than that obtained with GPM HIGH. The reason for this difference in the response of cars and trucks is that a feebate rate based on mpg translates into a higher rate per gpm for more efficient vehicles and a lower rate per gpm for less efficient vehicles. Many cars achieve high levels of efficiency, where the MPG feebates translate into a high effective feebate rate per gpm; consequently, the car market responds similarly to the GPM HIGH rates. Trucks generally achieve less fuel economy and consequently the MPG feebates are similar to the GPM LOW feebates.

The relative importance of manufacturer and consumer responses is about the same as with the other feebates—nearly all of the improvement in CAFE is due to manufacturers offering more fuel-efficient vehicles.

The forecasted impacts on fuel consumption, CO<sub>2</sub> emissions, consumer surplus, and manufacturer sales under the MPG LOW feebates are about midway between the impacts forecast for GPM LOW and GPM HIGH. This is because the car market responds as it does under GPM HIGH and the truck market responds as under GPM LOW. The MPG LOW feebates save 7.7 billion gallons of gasoline and provide net benefits to consumers of \$87 per household annually by 2010.

## **NONLINEAR LOW**

The NONLINEAR LOW program applies a high feebate rate at levels of gpm that are near the zero point and lower rates at levels of gpm that are farther from the zero point. The motivation for this type of feebates is found in the fact that the vast majority of vehicles have fuel-economy ratings that are quite



close to the fleet average. The NONLINEAR LOW feebate structure focuses the incentive for fuel-economy improvement on this segment of the market. The NONLINEAR LOW feebates can increase the feebate rate for most vehicles without commensurably increasing the magnitude of the highest and lowest feebates.

The range of feebates under this formula is close to GPM LOW, while the average feebate rate is closer to GPM HIGH. That is, the average change in feebates given a change in fuel consumption is increased without increasing the range of the feebates.

In the NONLINEAR LOW scenario, new-car fuel economy increases by about 16 percent by 2010. This is 2 percent more than under GPM LOW and 2 percent less than under GPM HIGH. New-truck fuel economy also lies between the GPM LOW and GPM HIGH results.

As a result of these fuel-economy improvements, fuel consumption and CO<sub>2</sub> emissions also lie between the GPM LOW and HIGH levels. However, consumer surplus is very close to that obtained under GPM HIGH.

## **SIZE-BASED**

The feebates examined so far tend to result in higher prices for domestic vehicles and lower prices for foreign vehicles. This is because domestic vehicles are generally larger and consume more fuel per mile than foreign ones. The intent of applying a size-based feebate, where the feebates are based on fuel consumption per unit of interior volume, is to lessen the impact of feebates on manufacturers that choose to provide a larger product line.

In the SIZE-BASED scenario, GPM LOW feebates are applied to trucks (because trucks are less amenable to size-basing), so the fuel-economy improvements in trucks are similar to those in GPM LOW. The SIZE-BASED feebates increase new-car fuel economy by 12 percent by 2010. Fuel savings by the year 2010 are 6.0 billion gallons. This improvement is lower than under GPM LOW because the average feebate rate on cars is lower under SIZE-BASED than under GPM LOW. This lower-than-average rate was specified to avoid a large increase in the range of the feebates (the difference between the largest and smallest feebate). If the range of the feebates is not a binding constraint on the magnitude of the feebate rate, then the rate for SIZE-BASED feebates could be raised such that they have similar overall effects on fuel economy and consumption as GPM LOW. That is, SIZE-BASED feebates

could protect domestic manufacturers while still achieving the same level of fuel-economy benefits. Under SIZE-BASED feebates, unlike any of the other scenarios, domestic sales are stimulated, while foreign sales decline. Between 1995 and 2010, discounted cumulative sales increase 0.2 percent for domestic manufacturers, and they decrease 3.2 percent for foreign manufacturers.

Of course, while the aggregate benefits can be as high under SIZE-BASED feebates as under GPM LOW, the *distribution* of improvements will differ. Under SIZE-BASED feebates, more fuel economy will be incorporated into smaller vehicles than into larger ones (because the feebate rate is higher for smaller vehicles).

It is important to note that this analysis does not incorporate the possibility that manufacturers might increase the size of their cars in response to SIZE-BASED feebates rather than (or in addition to) improving their fuel economy. Under SIZE-BASED feebates, manufacturers can obtain higher rebates or lower fees by increasing the interior volume of their vehicles, holding fuel economy constant. To the extent to which manufacturers actually do this, SIZE-BASED feebates will obtain less benefits than comparable consumption-based feebates.

## Conclusions

The net benefits of feebates consist of the gain in consumer surplus, plus the external benefits from lower emissions and reduced fuel consumption, minus the loss to domestic manufacturers and minus the administrative costs of the program. Consumers are found to experience net benefits. Sales of domestic vehicles are found to drop slightly (under consumption-based feebates) or rise slightly (under size-based feebates). Administrative costs are expected to be low. Overall, feebates are estimated to provide positive net benefits.

The same impact on total fuel consumption can be obtained with feebates based on gpm or mpg; hence, the choice between these two forms can be made on other grounds. Feebates based on mpg are probably easier for the public to understand. However, gpm feebates, unlike those based on mpg, place the same value on a gallon of fuel saved for all vehicles. This feature of GPM feebates seems sufficient for the extra burden of learning to be placed on the public.

Using the same zero point for cars and trucks has only a small effect compared to feebates with different zero points, shifting a small percentage of

consumers into cars and away from trucks. Because the manufacturer responses are the same in both cases, the impact on fuel consumption is due to the small shift from trucks to cars. For this reason, and because cars and trucks are often used for different purposes, it seems reasonable to apply separate zero points to cars and trucks. This approach is consistent with the precedent of CAFE regulation, which applies different fuel-economy standards to cars and trucks.

Nonlinear feebates have the potential advantage of increasing the average magnitude of rebates without increasing the range; however, they may confound people attempting to understand the basis for the magnitude of the feebates. Their use is recommended only if there is a constraint on how large the maximum rebates or fees can be.

Feebates that are not based on vehicle size result in slightly reduced sales of domestic vehicles and increased sales of foreign ones. Size adjustment reverses this situation, but it may also slightly reduce the energy and environmental benefits of the feebates by introducing counter-effective incentives. For example, it provides an incentive for manufacturers to increase the size of their vehicles so long as the size rises more than the concomitant increase in fuel consumption.

Finally, the dominance of the manufacturer response has several important implications. The first is that the effect of State-level feebates will likely be small, because, in most cases, it would be too costly and impractical for the manufacturer to modify only a small portion of its product line in response to feebates in a single State. California and New York are possible exceptions, each making up about 10 percent of the U.S. vehicle market. A Federal feebate would be required to ensure the benefits of a manufacturer response. Second, if there is any doubt that feebates placed on consumers will elicit a significant response from manufacturers, then placing the feebates on manufacturers is advisable. Third, if there is any uncertainty about whether manufacturers will actually respond to feebates on the basis of cost-effectiveness, then the impact of feebates could be much different than estimated (either larger or smaller).